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THE INFLUENCE OF MOTOR ACTIVITY ON THE DEVELOPMENT OF CARDIAC
ARRHYTHMIAS DURING EXPERIMENTAL EMOTIONAL STRESS

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vozniknoevniye serdechnykh aritmiy pri eksperimental'nom
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16. Abstract Studies on monkeys and rabbits have shown that the experimental emotional stress can produce various disorders of cardiac rhythm: sinus tachycardia, atrial fibrillation, ventricular, extrasystoles and paroxysmal ventricular tachysystoles. In these conditions the adrenalin content in the blood and myocardium is increased 3-4 times. Moderate motor activity leads to a relative decrease of adrenalin in the myocardium and arrest of cardiac-arrhythmias.					
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Experimental and clinical observations show that emotional /64** stress can lead to the development of cardiac arrhythmias and myocardial infarction [3, 4, 7, 13]. It is also the reason for development of cardiac arrhythmia and sudden death due to ventricular fibrillation [9, 15, 17, 18]. Literary data on the effect of motor activity in animals and man on the manifestation of disruptions in cardiac rhythm are contradictory. Thus, according to our preliminary observations [1] and the data of S. Kh. Tatoyan [8], ventricular extrasystole occurring in monkeys and rabbits during immobilization disappears under conditions of free behavior of the animals. In man, physical overexertion in combination with negative psychoemotional effects may lead to sudden death or ventricular fibrillation [2, 5, 16]. At the same time, prolonged hypokinesia in turn also causes the development of disruptions in the cardiac rhythm [11]. Studied in this work is the effect of motor activity on the development of cardiac arrhythmia and the redistribution of catecholamines in the blood and myocardium during experimental emotional stress.

Material and methods

The tests were conducted on 8 monkeys (4 rhesus monkeys aged 5-8 years and 4 Hamadryas baboons aged 6-8 years) and

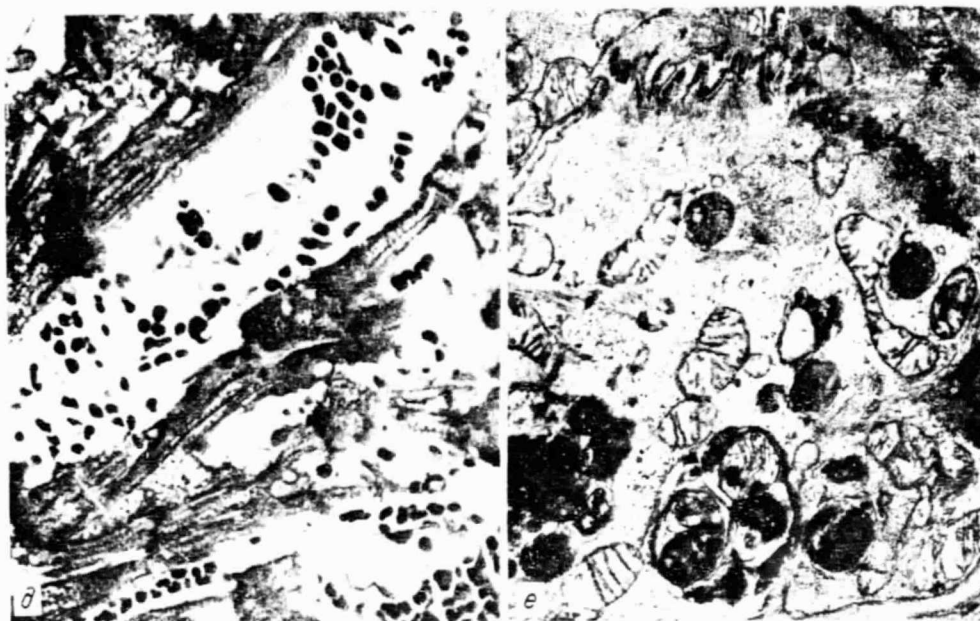
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and 50 rabbits of the chinchilla breed. The emotional stress in the monkeys was caused by periodic chronic immobilization for 2 hrs. daily for a period of 1½ weeks. In the rabbits, immobilization was conducted for analogous periods of time or combined with electrical stimulation of the negative emotiogenic centers -- the ventromedial nucleus of the hypothalamus. The stimulation was performed with the aid of stereotactically implanted bipolar electrodes using impulses with frequency of 50 Hz, duration of 0.5 msec, and current voltage of 100-400 μ A. The EKG in the rabbits during

/64a



/64b

Fig. 1. Morphological changes in the myocardium of the right ventricle during fibrillation of the heart ventricles.

a - 15 sec. of experiment: granular dystrophy of the cardiomyocytes. x200; b - 15 sec. of experiment: sections of supercontraction and superextension of the myofibrilla, swelling of the mitochondria and moderate destruction of their cristae, numerous glycogen granules in the sarcoplasm. x 18,000; c - 30 sec. of experiment: growth in dystrophic changes in the cardiomyocytes, vascular plethora and diapedetic hemorrhaging. x 400; d - 30 sec. of experiment: swelling and vacuolization of the mitochondria, expansion of the reticular sarcoplasmatic cistern. x21,000; e - 1 min. of experiment: increased diapedetic hemorrhaging in the interstitial space. x400; f - 1 min. of experiment: sequesters in the cardiomyocyte sarcoplasm surrounded by osmiophilic membranes. x21,000. a, c, e - stained with methylene blue with azure II and fuchsin; b,d, f - electronograms.

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Fig. 2. Ultrastructural changes in the cardiomyocytes of the right ventricle after ventricular fibrillation and subsequent cardiac defibrillation.

a - 30 sec. of experiment: extensive sections of cardiomyocyte lysis. x 18,000; b - 30 sec. of experiment: plethora of the capillaries, reduction in pinocytotic activity of the endothelium. x 24,000.

immobilization was registered in 3 standard leads and in the /65 monkeys in 12 leads on electrocardiographs "ELKAR-2" and "ELKAR-6". Under conditions of free behavior of the animals, the EKGs were recorded with the aid of the radiotelemetric system "Sport-4" or a special device developed at MIFI [Moskovskiy ordena Trudovogo Krasnogo Znameni inzhenerno-fizicheskiiy institut; Moscow Order of the Labor Red Banner Engineering-Physical Institute] by A. A. Svitka.

The fluorometric method was used to determine the content of adrenalin and noradrenalin in the blood and myocardium of the rabbits, as well as the level of DOPA and

dopamine in the cardiac muscle. In 30 animals, the change in the catecholamine content was studied during electrical stimulation of the negative emotional centers of the hypothalamus during immobilization and under conditions of free behavior. The animals were divided into 2 groups. One group included the rabbits, in whom the electrical stimulation of the hypothalamus was accompanied by moderate motor activity; the animals moved around the cage by hopping, sometimes stopping for several seconds, and then again beginning to hop at a moderate pace. In the other group of animals the stimulation of the hypothalamus was accompanied by sharply expressed motor activity; rapid continuous running and frequent attempt to hop out of the cage.

In 20 control intact animals, the catecholamine content was determined in a state of rest and under the influence of each of the studied factors: immobilization, motor activity, and electrical stimulation of the hypothalamus.

Results and discussion

The studies showed that in monkeys under conditions of emotional stress caused by periodic chronic immobilization, various disruptions of cardiac rhythm may develop. Thus, all 8 of the animals studied developed sinus tachycardia of up to 250 - 270 per minute during immobilization. Frequent ventricular extrasystole developed in 2 of the baboons and 2 of the rhesus monkeys (fig. 1). During the immobilization sessions, 2 animals exhibited a change in the EKG in the form of a gigantic T peak and a displacement of the S - T interval below the isoelectrical line. All these disruptions occurred most frequently during the first 5-6 immobilization sessions and, as a rule, passed after its cessation and the transfer of the animals to an ordinary cage.

As evidenced by radiotelemetric registration of the EKG, under conditions of free behavior of these monkeys, during

a state of rest or moderate motor activity, the ventricular extrasystole disappeared and normalization of the cardiac rhythm set in. The frequency of cardiac contractions during immobilization comprised an average of 215 ± 2.6 per minute, and under conditions of free behavior in a state of rest it was significantly lower -- 147 ± 6.8 per minute. The disruption of the cardiac rhythm and the change in EKG during immobilization occurred most often in monkeys with an expressed excitable type of central nervous system.

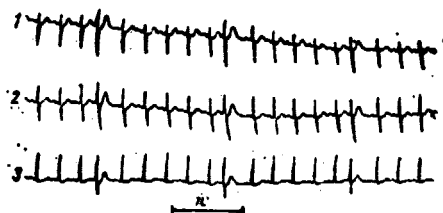


Fig. 1. Development of ventricular extrasystole in a *Hamadryas baboon* during immobilization.

1-3 - EKG in chest leads V_3 , V_4 , V_5 .

In 23 out of 30 rabbits during periodic chronic immobilization, particularly when combined with electrical stimulation of the negative emotigenic centers of the hypothalamus, there were also various disruptions in the cardiac rhythm. Most of these animals developed expressed sinus tachycardia -- up to 320-350 per minute (the initial cardiac contraction rate comprised an average of 270 ± 8.1 per minute). Under the influence of the indicated stress factors, 14 rabbits developed ventricular extrasystole, 4 - ciliary arrhythmia, 2 - paroxysmal ventricular tachysystole, and 3 exhibited a gigantic T peak and displacement of the S - T interval below the isoelectrical line. In 7 of the animals, despite the immobilization and stimulation of the hypothalamus, disruption of cardiac rhythm was absent... [Translator's note - remainder of paragraph illegible].

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In 15 of the rabbits, the change in cardiac rhythm was studied after cessation of the immobilization with continued stimulation of the negative emotiogenic centers of the hypothalamus. Under conditions of free behavior of the animals, the electrical stimulation of the ventromedial nucleus caused a clear passive-defensive reaction, which was accompanied by the manifestations of anxiety and fear.

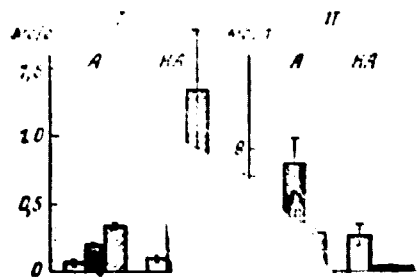


Fig. 2. [Translator's note: caption illegible]

The radiotelemetric study of the EKG showed that with an outwardly calm state or moderate motor activity of the animals, when they moved about at a moderate rate, the disruptions in cardiac rhythm passed. The adrenalin level in the blood and myocardium remained rather high, since each of the acting factors (electrical stimulation of the ventromedial nucleus of the hypothalamus and motor activity of the animal) lead to an increase in the catecholamine content. In this case the adrenalin content in the blood was equal to $7.92 \pm 1.62 \mu\text{g/l}$, in the myocardium -- $0.18 \pm 0.02 \mu\text{g/g}$. The level of noradrenalin in the cardiac muscle increased to $0.81 \pm 0.11 \mu\text{g/g}$, and in the blood its content dropped to 0 (fig. 2). On the contrary, during rapid continuous running and frequent attempts to jump out of the cage there again appeared a disruption in the rhythm in the form

of expressed sinus tachycardia, ventricular extrasystole, and paroxysmal ventricular tachysystole. Two of the animals died of ventricular fibrillation. The amount of adrenalin in the myocardium increased even more in this case -- to $0.33 \pm 0.02 \mu\text{g/g}$, and in the blood its level dropped to $2.81 \pm 0.20 \mu\text{g/l}$. The noradrenalin content in the myocardium increased to $1.32 \pm 0.43 \mu\text{g/g}$, and sharply declined in the blood (see fig. 2).

Thus, experimental emotional stress may lead to the development of various disruptions in cardiac rhythm. Their emergence is conditioned by the activation of the sympathetic-adrenal system [6, 9]. In monkeys during immobilization, sinus tachycardia and ventricular extrasystole are most often observed. These animals are particularly sensitive to the effects of stress factors [10], and the increase in frequency of cardiac contractions is one of the most important indicators of their emotional stress and prevailing sympathetic effects on the heart [12, 14]. Under conditions of free behavior, when the effects of immobilizations have ceased, the sinus tachycardia and ventricular extrasystole subside in the monkeys.

The studies conducted on the rabbits show that disruptions in cardiac rhythm may pass not only after cessation of the stress effects, but also under the influence of moderate motor activity of the animals. This may be conditioned by a redistribution in the catecholamine content: the relative reduction in the adrenalin content in the myocardium with a retention of its high level in the blood. At the same time these studies allowed us to establish the fact that sharply expressed motor activity of the animals during emotional stress effects, on the contrary, facilitates an increase in the content of adrenalin and noradrenalin in the myocardium (with a relative reduction of the adrenalin level in the blood) as well as the development of disruptions in the

cardiac rhythm up to the onset of ventricular fibrillation.

Conclusions

1. Motor activity significantly effects the emergence of disruptions in the cardiac rhythm and the redistribution of the catecholamine content in the blood and myocardium during experimental emotional stress.

2. Moderate motor activity leads to a relative reduction in the adrenalin content in the myocardium (with retention of its high level in the blood) and a cessation of cardiac arrhythmia.

3. Sharply expressed motor activity facilitates an /67 increase in the level of adrenalin and noradrenalin in the myocardium (with a relative reduction of their content in the blood) and a development of disruptions in the cardiac rhythm even up to ventricular fibrillation.

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